U and Th Background studies of Teflon and stock TeO_2 for CUORE

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To achieve its physics goals, CUORE must achieve a background of 0.01 counts/kg/keV/year in the 0νββ region. Because the CUORE experiment as currently designed does not include particle discrimination, any event that deposits energy in the region of neutrinoless double beta decay (0νββ) is a potential background. Over the past year, we have studied three possible sources of background for CUORE: radioactive contamination of TeO_2 powder, radioactive contamination of Teflon used in the Cuoricino experiment, and cosmic-ray induced activity in tellurium.

A sample of the TeO_2 stock powder from Great Western Inorganics, Arvada, CO, which is used by a vendor being considered for CUORE crystal production, has been analyzed by direct gamma counting at our Oroville Low Background Facility. A 3617 g sample was counted for 11320 minutes. Results were consistent with 220 ± 40 ppt of uranium. All gammas used for the uranium analysis were daughters of ^{226}Ra. Since none of the low-intensity gammas from earlier members of the series were observed, we cannot say whether uranium itself is present in this material. No thorium series or gammas were observed above the system background levels, with a 1σ uncertainty of 85 ppt. Potassium gammas were also not observed above background, corresponding to an upper limit of 100 ppb. This sample of TeO_2 appears to be measurably lower in radioactivity than the TeO_2 used as starting material for the Cuoricino crystals grown in Shanghai. The radioactive content of the Shanghai material is reported to be 1-2 ppb U, 1 ppb Th, and 200 ppb K. Longer direct counting time at Oroville could produce results with 1σ uncertainties lower by about a factor of two than those listed with present results. However, it may also be useful to count a sample from a different lot supplied by Great Western Inorganics.

To determine the level of radioactive contamination in the Teflon used in Cuoricino, we used neutron activation analysis. The sample consisted of six 6.4 g pieces of Teflon, machined using steel tools from the Cuoricino stock. Each piece was a cylinder, 1.6 cm in diameter, and 1.6 cm high. The sample was packed in a 10 cm long tube with a standard pottery monitor at either end. The irradiation was carried out at the McClellan Nuclear Radiation Center's rabbit facility. It was irradiated for 33 minutes at 1.8 MW. The sample was allowed to cool over the weekend, and then was shipped back to LBL for gamma counting. The individual Teflon pieces were cleaned with HF before counting to remove surface contamination. Later, the top and bottom surfaces were also machined off in order to further observe surface effects. None were observed. Gamma spectroscopy has indicated the presence of 150 ppt of U (σ = 10-20%) and 250 ppt of Th (σ < 10%). The plots in Figure 1 show the activity of ^{239}Np and ^{233}Pa, which are the neutron activation products of U and Th, respectively, as a function of time. The activities decay with the proper half lives. It is unknown whether the long-lived parent nuclei are in equilibrium with their shorter-lived daughter nuclei. In the future, we will study samples of Teflon from other sources in pursuit of cleaner material for CUORE.

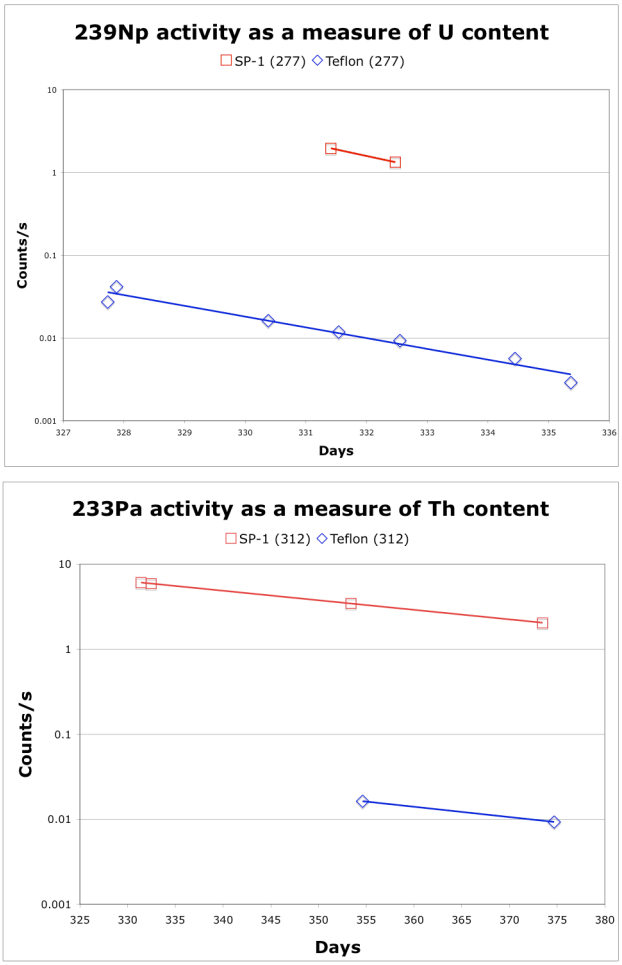

FIG. 1: Activity of ^{239}Np and ^{233}Pa as a function of time. The concentration of U and Th are determined by direct comparison between the activity of the Teflon samples and the standard pottery monitors. The fits agree with the expected decay rate of the isotopes.

REFERENCES

[1] R. Ardito, *et. al.*, hep-ex/0501010 (2005).